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ALLOCATION OF RESEARCH LABORATORY RESOURCES: A STUDY OF RESOURCES ALLOCATION USING CRITERIA OF MILITARY SIGNIFICANCE AND INVESTMENT RISK

Warren James Millard

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THESIS

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A STUDY OF RESOURCES ALLOCATION USING CRITERIA OF
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by

Warren James Millard

Thesis Advisor: J. K. Arima

March 1973

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Allocation of Research Laboratory Resources:
A Study of Resources Allocation using Criteria of
Military Significance and Investment Risk

by

Warren James Millard
Lieutenant, United States Navy
B.S., United States Naval Academy, 1967

Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

The problem is defined as examining a list of the research projects presently sponsored by the Department of the Navy under GOR-43 and analyze the ordered project listings as ranked by panels composed of persons with interest in those projects.

Data consisted of project priority rankings of 193 judges composing 9 separate panels, each judge ranking the projects twice in priority order; once considering the practical significance of the project and once considering the possibility of a successful research effort. Project rankings of judges within each panel were scaled using the FORD procedure and the 9 panel rankings then investigated for similarities using methods of cluster analysis.

The results showed that no 2 judge panels submitted highly correlated rankings of the 18 projects, but that under each criterion several project clusters were evident, indicating equal research emphasis desired by the panels.

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I. INTRODUCTION

There exists within the Department of the Navy, many organizations with varying convictions about which Navy Personnel Research and Navy Training Research Programs should receive priority when allocating research funds and research time. The diverse opinions of program emphasis are due partly to the different compositions of the groups, partly to the different functions of the groups and partly to the relationships of the groups to other organizations both inside and outside the Department of the Navy.

Undoubtedly, those who make the final decisions have the greater number of relevant facts upon which to base their decision. They probably exert greater effort to the decision-making process itself than their critics might. Thus their decisions should be the best "all factors considered" decisions. Nevertheless, an examination of the diversity of opinions among different groups should help their decision-making process by providing additional information and by pointing out areas where closer agreement among various groups would promote the research effort.

The objective of this paper is to draw, from various groups, data concerning which programs they feel should be studied, analyze the group decisions and examine

similarities and dissimilarities of their priority project choices.

The nature of the problem is two-fold.

1. Compare the groups by comparing their choices of which projects should receive priority when allocating research laboratory resources. Establish communities of judge groups whose priority rankings displayed a degree of similarity.

2. Examine a list of projects currently being studied by the Bureau of Naval Personnel and associated research laboratories. Determine if there exists projects which inter-group consensus shows should receive either high or low priority when allocating research laboratory resources.

The method chosen to compare the judge groups was by means of a two-dimensional plot where inter-point distances on the plot are a monotonic function of the judge group similarities. More specifically,

$$r_{ij} > r_{jk} \Rightarrow d_{ij} < d_{jk}$$

r_{ij} = a correlation measure between groups i and j.

d_{ij} = the inter-point distance for points i and j on the two-dimensional plot.

By examining the resulting plots using methods of cluster analysis, those judge groups whose project priority rankings compared favorably were readily evident.

The methods for comparing the various projects were the same as for the judge groups except that a dissimilarity vice correlation measure was utilized for inter-object comparison. The technique for determining the plot accepted either statistic as input. The resulting plot displayed the projects as an inverse monotonic function of the dissimilarity measure. Specifically,

$$t_{ij} < t_{jk} \Rightarrow d_{ij} < d_{jk}$$

t_{ij} = the measure of dissimilarity between projects i and j. d_{ij} = the inter-point distance for points i and j on the two-dimensional plot.

Methods of cluster analysis discerned those projects which received similar rankings on the priority scales of the judge groups.

Comparison of the mean ranking for each project over all judge groups showed which projects were ranked high, low, etc. The variance of the mean ranking for each project indicated the consistency of its ranking by the judge groups, e.g., the projects with the lowest rank variance were ranked most consistently by all groups.

II. DATA DESCRIPTION

The data source for this study consisted of approximately two-hundred individual judges, each ranking the same eighteen projects on a priority ladder. That project which the judge felt should receive top priority was ranked first; the second most important was ranked second, etc. In addition, each judge was allowed to indicate programs which he believed should receive equal emphasis by placing them (up to six) in the same group. To increase the validity of the data, judges were asked to rank only the projects which they felt knowledgeable about and competent to rank.

Each judge produced two priority ladders, one ranked using the criterion of Military Significance of the project and one ranked using the criterion of Investment Risk of the project. The two criteria are explained in the following paragraph.

A. PROJECT RANKING CRITERIA

The two major considerations when deciding upon which projects to expend research resources are the potential Military Significance of the program and the Investment Risk of the program. The judging groups of this study were asked to construct priority ladders of the considered programs under each of those two considerations.

1. <u>Criterion A. Military Significance</u>

Military Significance refers to the needs of the Navy. The projects were ranked on the basis of which would yield the greatest payoff to the Navy if the research was successful. Those projects thought to have high military significance were ranked high and so on, down to those of low military significance. The probability of a solution being achieved was not considered under this criterion, only the significance of the solution if it were achieved.

2. <u>Criterion B. Investment Risk</u>

Investment Risk refers to the probability of a successful research effort regardless of the value to the Navy of the payoff. The project orderings represented each judge's belief of which problems had a high probability of being successfully solved (ranked high) and which had a lower probability of being solved (ranked lower). A research effort was defined as successful if a solution to problems or significant improvements in the present state could be developed within a period of ten years.

B. THE JUDGE GROUPS

The judge groups chosen for this study represent those organizations which are vitally interested in the allocation of research resources to the various projects. The list of the nine groups is contained in Appendix A.

They represent a cross-section of persons directly connected with the Bureau of Naval Personnel and with the Naval Personnel Research Laboratories. Both managers and professional workers are included as judges. In addition, group number 7 is composed of persons who are users of research products; group number 8, evaluators of research efforts; and group 9, contracted workers on research programs. Accordingly, none of these last three groups is directly involved in selecting projects for emphasis in research.

C. THE PROJECTS STUDIED

The projects selected for study are ones of current high interest within the Department of the Navy. Appendix B lists and describes the projects. One of the objectives of this study was to determine if the judge groups felt that program priority lists should be reassessed. The projects considered represent all those that Personnel Logistics (General Operating Requirement 43) is currently concerned with, plus the additional project of R & D Resources Management (No. 16).

III. CALCULATIONS ON DATA

The raw data submitted by each individual judge was in the form of two priority ladders, one for each ranking criterion. To facilitate comparing the judge groups, a single composite ranking of projects for each group, which represented the preferences of each judge in that group, had to be derived.

A. THE FORD PROCEDURE

The technique for developing a composite ranking for each judge group is known as the FORD PROCEDURE [Ref. 1]. Basically, the program determines a weighted value for each project. The weight statistic is calculated from a win-loss matrix by solving iteratively the equation

$$w_i^{n+1} = \frac{\sum_j a_{ij}}{\sum_j \frac{a_{ij} + a_{ji}}{w_i^n + w_j^n}}$$

where

a_{ij} = the number of times project i was preferred to project j by all judges in the group.

w_i^n = the weighted value assigned to project i on the n th iteration.

w_i^1 = the win percentage for project i on the first iteration.

It should be noted that the FORD PROCEDURE produces a composite judgment that reflects the contribution of individual judges according to the number of judgments he makes.

Several commendable characteristics which illustrate why the FORD PROCEDURE is especially applicable to this study are,

1. A judge or ranker needed not rank all the projects, only those he felt knowledgeable about and competent to rank.

2. Each judge could make his ranking as coarse or as fine as he desires. There was no restriction on the number of judgmental categories he may use.

3. A judge had no requirement for a fixed distribution of projects among the categories except that no more than one-third of the projects could be placed in any one category.

4. A judge could indicate projects of tied ranking by placing them in the same category.

The input to the FORD PROCEDURE, as run on the IBM/360 computer, was composed of each individual judge's ranking of some or all of the eighteen projects, ordered under Criterion A or B. The program considered all judge rankings of judges in one group and calculated a weighted value for each project. By ordering the projects with the highest weight first, a single composite ranking of projects representing all the judges in that group was obtained.

B. DATA MATRIX TRANSFORMATION

After computing a composite ranking for each group, the data for analysis had been reduced to an 18 x 18 matrix M. 'Rank positions' were labels on the ordinate and 'judge groups' were the labels on the abscissa. One additional ranking was added to the data matrix as column 10. It represented the projects ranked high to low as reflected by current fiscal year funding. Columns 1 through 9 of matrix M represented the priority rankings of the projects by the judge groups under the A criterion. Columns 11 through 19 represented the priority rankings of the judge groups 1 through 9 respectively, under criterion B. Element m_{ij} showed which project was ranked in the i th position by judge group j. Appendix C contains matrix M.

To enable easier calculation of correlation coefficients between judge groups and between projects, the matrix M was transformed to a matrix N, 18 x 19. Matrix M had 'project number' on the ordinate and 'judge group' on the absicssa. Thus the element n_{ij} represented the ranking of project i by judge group j.

C. CORRELATION BETWEEN JUDGE GROUPS

From matrix N the correlation between judge groups was calculated using the formula

$$r_{ij} = 1 - \frac{6 \sum_k (d_{ij})^2}{N(N^2-1)}$$

where

d_{ij} = the difference between the ranking of project k by judge groups i and j.

N = the number of ranks.

k = an index to facilitate stepping through each of the 18 projects. The correlation coefficient r_{ij} has the advantage of not requiring any assumption on the distribution of the data. Matrix R in Appendix D displays the r_{ij} values.

D. PROJECT COLLATION

A statistic was required that would quantify the relationship of project i to project j. It was decided that the best method was to compare their respective rankings by the judge groups. By calculating a difference in the mean ranking of each project, no consideration would be given to the variance of the rankings. Note that if projects r and s with mean rank difference equal to X have small rank variance, they are 'farther apart' than projects u and v with a difference in mean ranks equal to X and with

large rank variance. Therefore, the statistic t_{ij} was developed and used as a dissimilarity measure.

$$t_{ij} = \frac{\left| MR_i - MR_j \right|}{\sqrt{(STD_i)(STD)_j}}$$

where

MR_i = the mean rank of project i over the judge group rankings.

STD_i = the standard deviation of the rankings of project i. Project mean ranks, standard deviation of the rankings, and the tabled t_{ij} statistic are shown in Appendix E. The smallest value for standard deviation of project ranking was 1.68; therefore, the problem of a very small STD_i value disproportionately affecting the t_{ij} statistic was not encountered.

IV. MULTIDIMENSIONAL SCALING ANALYSIS

The method chosen to compare the various judge groups and to compare the projects was multidimensional scaling analysis. The particular technique employed was non-metric Smallest Space Analysis (SSA), and has evolved through studies by Shepard, Kruskal, Guttman and Lingoes [Refs. 2-6]. The computer program used was developed at the University of Michigan by Guttman and Lingoes and is designated Smallest Space Analysis - I (SSA-I) [Ref. 7]. The program finds a set of coordinates for each of the n points (n judge groups) in an m dimensional Euclidean space such that the distance between points is a monotonic function of inter-judge group correlation. More precisely, given a set of n objects for which there is a defined distance function, such as object correlation ranks ρ_{ij} on the n(n-1)/2 pairs of points, find that set of real numbers, x_{ia} ($i = 1, 2,.., n$; $a = 1, 2,.., m$) such that if

$$d_{ij} = [\sum_{k=1}^{m} (X_{ik} - X_{jk})^2]^{1/2}$$

then $d_{ij} < d_{kl}$ whenever $\rho_{ij} < \rho_{kl}$.[1] The concept of the distant function ρ_{ij} was important to the scaling analysis and deserves amplification. When reading as computer

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[1] Lingoes, J. C., New Computer Developments in Pattern Analysis and Nonmetric Techniques, paper presented at the 1964 IBM Symposium of Statistics, Paris: Gauthier-Villas, 24 November 1966.

input the correlation matrix R, the distance function ρ_{ij} refers to the rank of correlation coefficient r_{ij} in an ordered column vector V. For example, the highest r_{ij} value was assigned $\rho_{ij} = 1$, the second highest r_{ij} was assigned $\rho_{ij} = 2$ etc. The meaning of '$d_{ij} < d_{kl}$ whenever $\rho_{ij} < \rho_{kl}$' is then obvious.

The practice of utilizing only the ranks of the coefficients and not the actual values when determining optimal point orientation on the multidimensional plot is the nonmetric method. Nonmetric rather than metric constraints permit bypassing strong linear and distributional assumptions required of metric methods. Defining a true metric on psychological data, as was the case in this problem, was impossible. To enable the plotting of a meaningful display the number of Euclidean dimensions is limited to m = 2. A true metric constraint denies that possibility due to the strict linear distance measurements between points. A nonmetric monotonic distance function allows for the reduction to a two dimensional display while still maintaining a meaningful plot. Several goodness-of-fit coefficients used in this study confirm the nonmetric assumption as acceptable.

A. SMALLEST SPACE ANALYSIS (SSA-I) ALGORITHM

The algorithm for determing the optimal orientation of points representing the n objects proceeds as follows.

STEP 1: Read in the data matrix R of inter-group correlation values or the data matrix T of inter-project dissimilarity values.

STEP 2: Sort the data values from large to small if similarities and small to large if dissimilarities. Assign ordered ranks of 1 to n(n-1)/2 to the ordered vector. Indicate the rank of element r_{ij} by ρ_{ij}.

STEP 3: Construct a matrix C by

$$c_{ij} = \begin{cases} 1 - \rho_{ij}/[n(n-1)/2] & i \neq j \\ n - \sum\limits_{\substack{j=1 \\ i \neq j}}^{n} c_{ij} & i = j \end{cases}$$

Solve for the Eigenvectors and Eigenvalues of C. The set of Eigenvectors x_{ia} $(i = 1, 2, \ldots, n;\ a = 1, 2, \ldots, m)$ is the initial orientation of the n points in the m dimensional Euclidean space.

STEP 4: Calculate the inter-point distances over the m dimensional space.

$$d_{ij} = [\sum_{k=1}^{m} (x_{ik} - x_{jk})^2]^{1/2}$$

Order the distances d_{ij} in a row vector with n(n-1)/2 elements.

STEP 5: Redefine the ρ's as the d's permuted to maintain the rank order of the original distance function and designate them d*.

STEP 6: Calculate a measure of effectiveness, the phi coefficient.

$$\phi = \sum_{i=1}^{n-1} \sum_{j=1+1}^{n} (d^*_{ij} - d_{ij})^2$$

STEP 7: Calculate a new C matrix on the basis of the d's and the d*'s.

$$c_{ij} = \begin{cases} 1 + \sum_{k=1}^{n} d^*_{ik}/d_{ik} & i=j \\ 1 - \dfrac{d^*_{ij}}{d_{ij}} & i \neq j \end{cases}$$

where $d_{ii} = 0$, $d^*_{ii} = 0$, and $\dfrac{d^*_{ii}}{d_{ii}} = 0$ by convection.

STEP 8: Calculate a new set of point coordinates

$$X^{t+1}_{ik} = 1/n \sum_{j=1}^{n} X^{t}_{ik}\, c_{ij} \qquad k=1,2,\ldots,m$$

STEP 9: Calculate again the inter-point distances as per step 4 and repeat steps 5, 6, 7 and 8. Continue until the normalized phi coefficient indicates further adjustment of points will not advance the state of the inter-point distance and original distance function relationship toward actual monotonicity.

B. GOODNESS-OF-FIT MEASUREMENTS

1. Guttman-Lingoes Coefficient of Alienation

Consider a scattergram of $n(n-1)/2$ points on coordinates d_{ij} vs d^*_{ij}. Maximizing a statistic μ

is defined as minimizing the alienation of plotted points from a regression line through the origin. The coefficient of alienation is $K = (1 - \mu)^{1/2}$. The statistic μ is a rank-order correlation coefficient between $\rho_{ij} = d^*_{ij}$ and d_{ij} • μ equals 1 when $d_{ij} = \alpha\, d^*_{ij}$ for some constant of proportionality α and it follows that the coefficient of alienation K would equal zero.

2. Kruskal's Stress

Kruskal's stress is derived from a two-dimensional plot of d^*_{ij} vs ρ_{ij} and is a statistic quantifying how well the given configuration of points represents the data. A monotonic increasing piece-wise linear line is drawn connecting the points. The points d_{ij} are also plotted on the graph. The distance $(d_{ij} - d^*_{ij})$ is defined as the horizontal difference between the actual distance d_{ij} and the desired distance d^*_{ij} . Kruskal's stress is defined as,

$$S = \sqrt{\frac{\sum (d_{ij} - d^*_{ij})^2}{\sum (d_{ij})^2}}$$

Application of the statistic has shown that for any value of S less than .20, the plotted configuration of points is a good representation of the original data. Zero stress indicates complete compliance with the monotonic constraint.

V. CALCULATION RESULTS

To accomplish the objectives of this study of comparing the judge groups under each of the ranking criteria, and of comparing the projects being ranked, the Smallest Space Analysis - I was employed several times.

A. JUDGE GROUP COMPARISON

1. Comparison of Judge Groups under Criterion A

Columns 1 through 10 of matrix N in which n_{ij} represented the ranking of project i by judge group j under Criterion A (Military Significance) and column 10 representing fiscal year funding, were taken for the first calculation. The correlation matrix R was calculated for the measure of similarity between judge groups. r_{ij} $(i=1, 2,\ldots,10;\ j=1, 2,\ldots,10)$ was then used as input to SSA-I.

Table I shows the resulting point positions representing the optimal orientation of each judge group with respect to the other nine. The values for Guttman-Lingoes' coefficient of alienation of .290 and Kruskal's stress of .243 were both marginal values and indicated that an actual monotonic relationship between similarities and inter-point distances was not attainable. The plot of points, Figure 1, did not indicate any clustering or significant similarity among judge group rankings.

TABLE I

PLOT OF JUDGE GROUPS

RANKING UNDER THE MILITARY SIGNIFICANCE CRITERION

Judge Group	Plot Coordinates	
1	6.268	59.664
2	-50-775	-69.316
3	6.069	-16.553
4	-100.000	-37.483
5	-80.282	50.179
6	100.000	-14.333
7	19.227	-100.000
8	36.415	32.546
9	-26.288	20.693
10	-59.613	-7.008

Guttman-Lingoes' Coefficient of Alienation = 0.29037

Kruskal's Stress = 0.24326

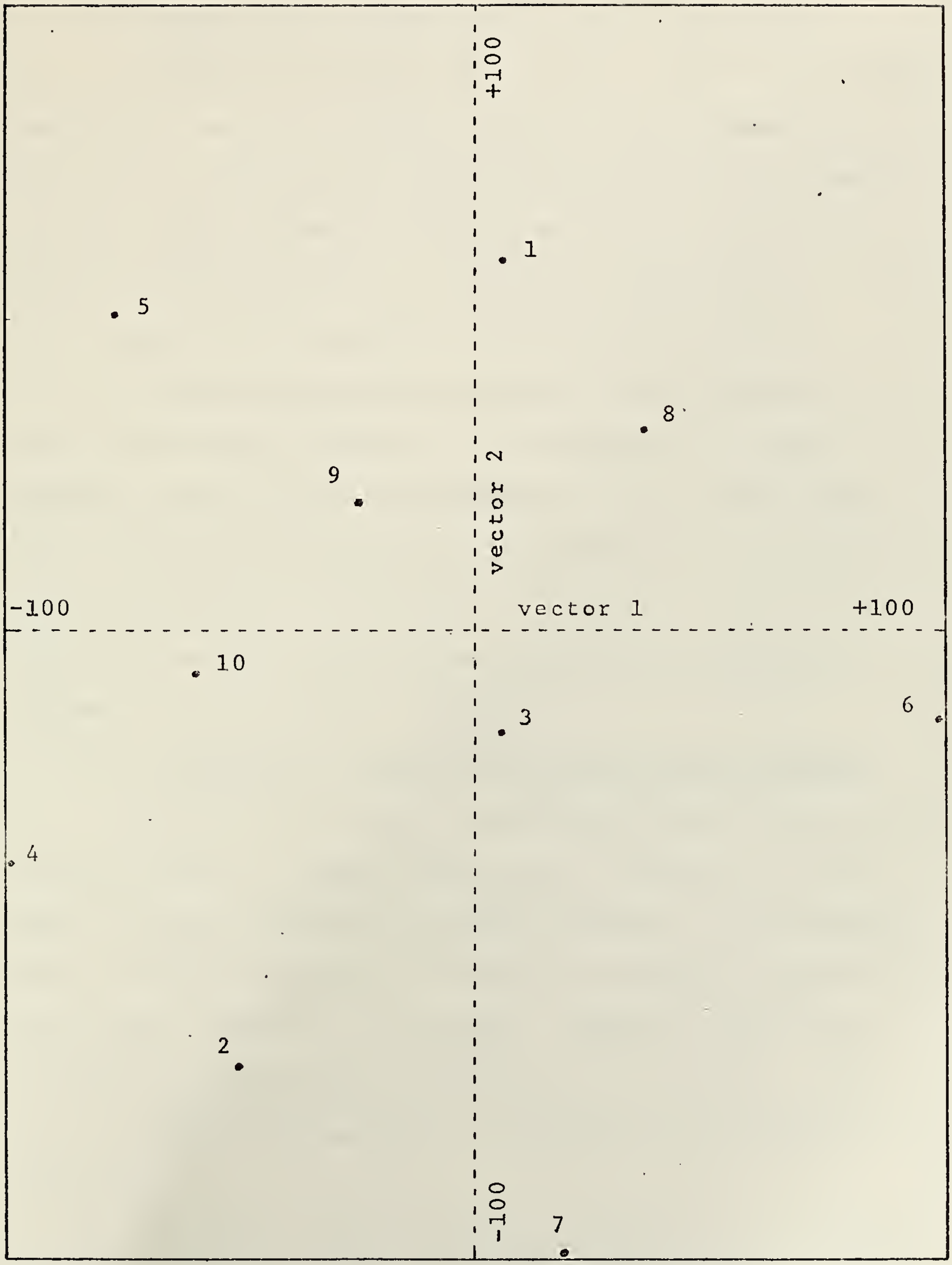

Figure 1. Plot of Judge Groups Ranking under the Military Significance Criterion.

2. <u>Comparison of Judge Groups under Criterion B</u>

Columns 10 through 19 of matrix N with n_{ij} representing the priority rank of project i with respect to fiscal year funding and judge groups 1 through 9 respectively, under Criterion B were used for the second run. The correlation values r_{ij} (i=10,11,...,19; j=10,11,...19) from matrix R of Appendix D was the input to SSA-I.

Table II shows the resulting point positions on the two-dimensional display. The values for Guttman-Lingoes' coefficient of alienation of .257 and for Kruskal's stress of .214 were again marginal. The plot of points in Figure 2, by being very scattered, indicated that none of the judge groups agreed to a significant degree on their project rankings.

3. <u>Comparison of Judge Groups under Both Criteria</u>

Neither the plot of judge groups under Criterion A nor the plot of judge groups under Criterion B indicated a strong similarity in group decisions. By plotting all 19 "groups" together it would be possible to see if any groups submitted very similar rankings under both criteria. Correlation coefficients r_{ij} (i=1,2,...,19; j=1,2,...,19) from matrix R of Appendix D were input to SSA-I.

Table III lists the plot positions. The Guttman-Lingoes' coefficient of alienation was .190 and the Kruskal stress was .167. The values indicated an excellent

TABLE II

PLOT OF JUDGE GROUPS

RANKING UNDER THE INVESTMENT RISK CRITERION

Judge Group	Plot Coordinates	
1	89.897	38.945
2	33.497	-94.012
3	-100.000	-45.473
4	-83.266	57.879
5	33.039	69.747
6	100.000	-53.064
7	16.167	-16.339
8	-23.906	-100.000
9	-1.639	23.583
10	-17.311	112.864

Guttman-Lingoes'
Coefficient of Alienation = 0.25766

Kruskal's Stress = 0.21421

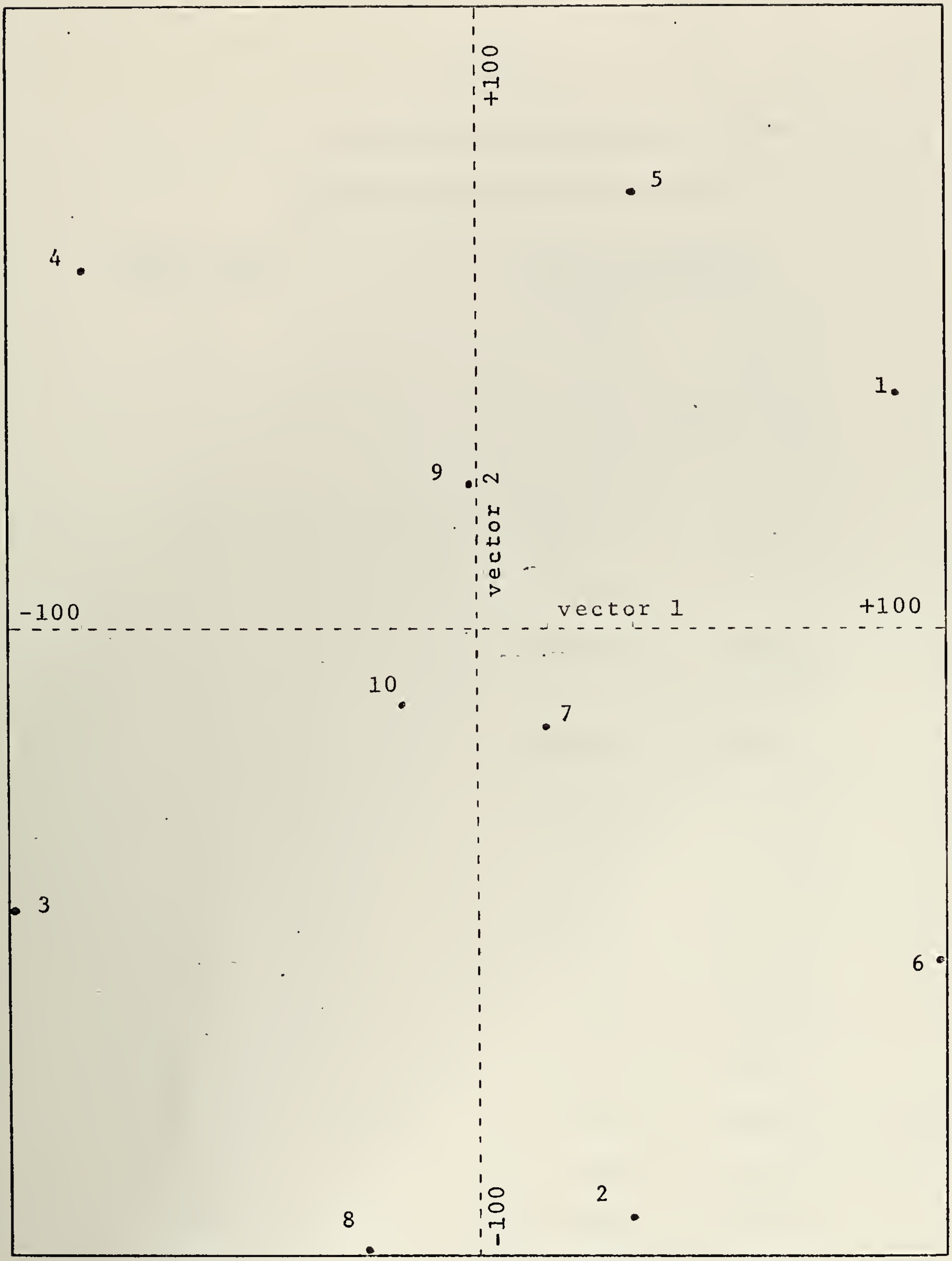

Figure 2. Plot of Judge Groups Ranking under the Investment Risk Criterion.

TABLE III

PLOT OF JUDGE GROUPS

RANKING UNDER BOTH CRITERIA

Judge Group	Plot Coordinates	
1	-18.158	24.269
2	-6.882	10.933
3	51.030	-100.000
4	-90.134	-24.549
5	-21.517	-80.273
6	-8.888	-40.472
7	-64.799	-59.218
8	-96.362	-48.063
9	-100.000	-94.551
10	18.474	-83.546
11	74.592	-7.040
12	81.520	-25.029
13	86.038	-42.891
14	59.298	-25.100
15	66.162	-65.892
16	72.194	-28.508
17	-9.576	-16.639
18	62.696	-71.514
19	100.000	-81.553

Guttman-Lingoes'
Coefficient of Alienation = 0.19045

Kruskal's Stress = 0.16754

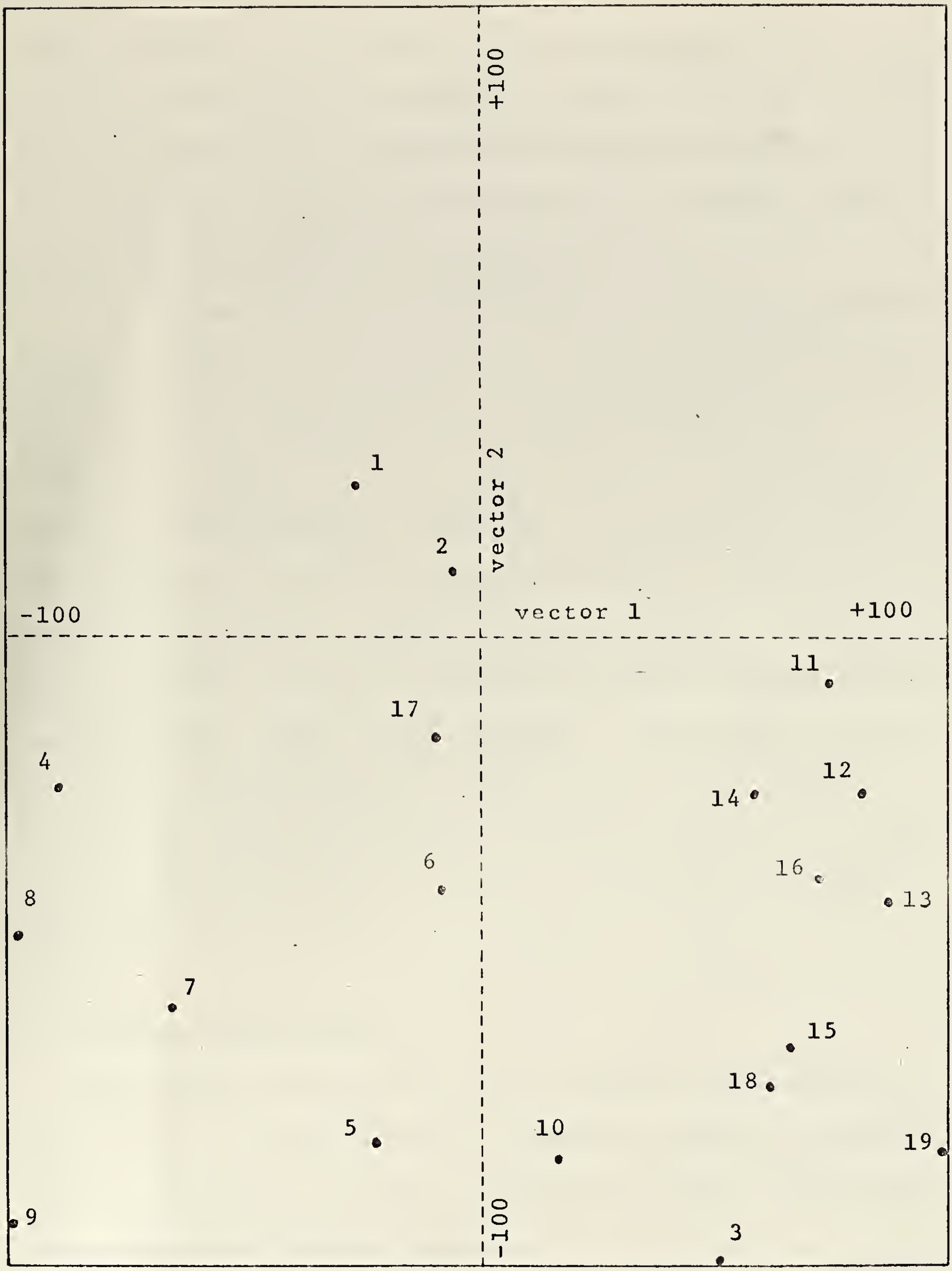

Figure 3. Plot of Judge Groups Ranking under Both Criteria.

plot in terms of variation from the regression line for the G-L coefficient as detailed in paragraph IV C 2. The Kruskal stress also indicated excellent correlation of plotted values with the monotonically increasing line on ρ_{ij} vs d^*_{ij} as explained in paragraph IV C 2.

Figure 3 was not applicable to clustering consideration because it represented the judge groups as nineteen separate entities, i.e., each judge group was represented twice. However, one thing was clearly indicated. Each judge group submitted significantly different rankings for each of the two criteria. With the exception of group 3 under Criterion A (point 3) and group 7 under Criterion B (point 17), there was no overlapping of the judge group rankings. The results indicated that the judges actually did consider the criteria of Military Significance and Investment Risk when ranking their projects. That is an important argument for data validity.

B. PROJECT COMPARISONS

The second objective of this study was to compare the projects and examine possible groups of projects that the judges considered of equal importance or that judge group consensus rated high or low.

1. <u>Comparison of Projects Ranked under Criterion A</u>

The eighteen projects as ranked under Criterion A plus the fiscal year funds ranking were the first of the

project groups considered. The entries of matrix T_A in Appendix E are values of the interpoint dissimilarity measure t_{ij} for the Military Significance Criterion. The input to SSA-I was the matrix T_A.

Table II shows the point position representing the projects on the two-dimensional plot. The value of Guttman-Lingoes' coefficient of alienation was .067 and Kruskal's stress was .053. Both values indicate that the resulting plot was an excellent reflection of the original data as determined by the distance function ρ_{ij}. Figure 4 showed definite clusters of projects. The rule chosen for defining a cluster of c points was that each point be within 20.0 units of the other c-1 points of the cluster. (The longest possible inter-point distance on the plot was 282.0 units.) Using that rule, 2 major clusters of 3 or more points were established. One cluster was composed of projects 5, 8 and 18, and the other cluster was composed of projects 3, 10, 12, 14 and 15. Minor clusters were established between projects 7 and 9, and between projects 4 and 16. The implication drawn from the clusters was that the projects in each cluster were considered of equal priority by the judge groups when ranking under the Military Significance Criterion. The SSA-I plot is more meaningful than a standard correlation statistic because each point was plotted with respect to the other n-1 points.

TABLE IV

PLOT OF PROJECTS

WHEN RANKED UNDER THE MILITARY SIGNIFICANCE CRITERION

Project No.	Plot Coordinates	
1	88.636	-46.802
2	-80.882	22.898
3	5.479	-82.690
4	50.223	-48.019
5	-34.760	-52.799
6	-16.022	-75.868
7	38.913	-67.702
8	-41.815	-56.905
9	30.572	-66.946
10	16.792	-66.719
11	-81.456	-100.000
12	3.653	-77.032
13	100.000	-26.187
14	11.188	-74.394
15	16.804	-87.316
16	55.806	-37.771
17	-100.000	-51.790
18	-51.634	-49.414

Guttman-Lingoes' Coefficient
of Alienation = 0.06728

Kruskal's Stress = 0.05308

Figure 4. Plot of Projects when Ranked under the Military Significance Criterion.

A correlation statistic reflects the collation between two points regardless of each point's relationship to the remaining points.

2. Comparison of Projects under Criterion B

The entries of matrix T_B in Appendix E were used as the SSA-I input for comparing projects as they were ranked by the judges under the Investment Risk Criterion.

Table V shows the point positions, the Guttman-Lingoes' coefficient of alienation as .030 and the Kruskal stress as .021. Again the values indicated an excellent fit with respect to the plotting constraints. Figure 5 showed the project point orientation. Using the rule that inter-point distances be less than 20.0 units for each cluster point, three major clusters were established. One cluster was composed of projects 3, 15, 17 and 18; another was composed of projects 1, 13 and 14, and the third of projects 6, 7 and 10. A minor cluster between projects 12 and 16 was also in evidence. Therefore, ranking on the basis of Investment Risk the judges felt the clustered projects entailed similar risk.

3. Comparison of Projects using Both Criteria

In actual practice both Military Significance and Investment Risk are considered when allocating research resources. For that reason a plot of the projects considering both criteria was desired. Matrix T_{AB} of Appendix E was used as the input for SSA-I. It was derived by considering the judges as nineteen separate groups.

Table VI displays the point positions. The Guttman-Lingoes' coefficient of alienation of .026 and the Kruskal stress of .018 both indicated an excellent plot in terms of meeting the plotting algorithm constraint criteria. Figure 6 showed several clusters, the major ones being projects 5, 8, 17 and 18, and projects 4, 6 and 7. Minor clusters consisted of points 9 and 11, points 3 and 15, points 12 and 14, and points 1 and 16. Considering the projects under both ranking criteria, those clusters represented the projects which the judge groups felt should receive equal emphasis for research.

TABLE V

PLOT OF PROJECTS

WHEN RANKED UNDER THE INVESTMENT RISK CRITERION

Project No.	Plot Coordinates	
1	81.826	-31.333
2	-85.361	15.915
3	-54.677	-66.792
4	-68.344	-52.507
5	-100.000	-29.425
6	-18.818	-74.158
7	-30.314	-64.395
8	-67.295	-76.211
9	-82.586	-4.289
10	-20.116	-87.728
11	26.285	-100.000
12	71.931	-43.641
13	100.000	-23.824
14	94.434	-27.973
15	-48.304	-61.729
16	68.200	-54.758
17	-45.503	-70.721
18	-43.436	-64.363

Guttman-Lingoes'
Coefficient of Alienation = 0.03073

Kruskal's Stress = 0.02190

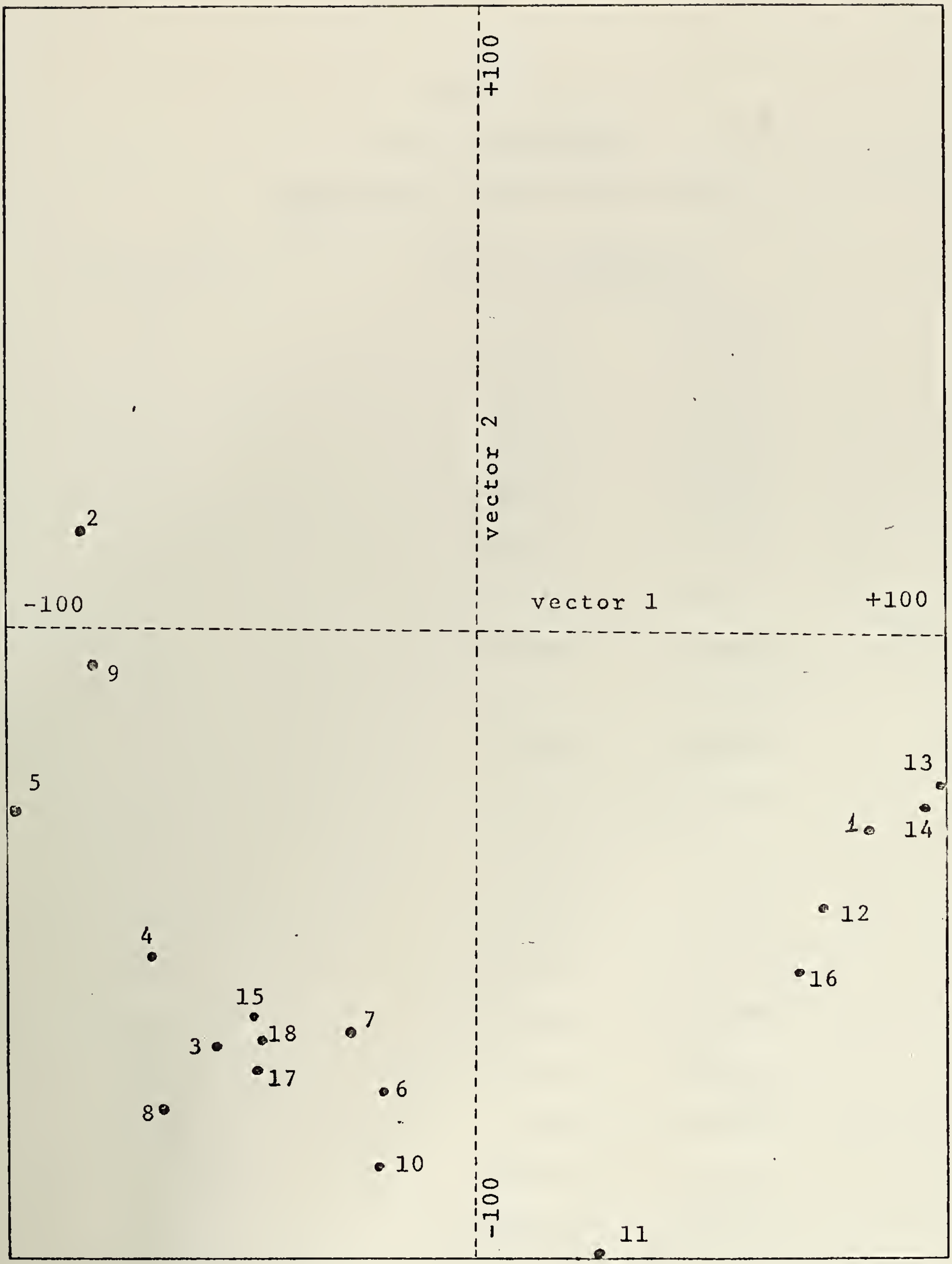

Figure 5. Plot of Projects when Ranked under the Investment Risk Criterion.

TABLE VI

PLOT OF PROJECTS

WHEN RANKED UNDER BOTH CRITERIA

Project No.	Plot Coordinates	
1	84.667	-38.574
2	-100.000	46.714
3	-55.133	-88.801
4	-30.757	-83.865
5	-89.757	-35.684
6	-37.145	-96.417
7	-21.369	-88.825
8	-96.979	-66.706
9	-58.968	-63.651
10	-13.578	-100.000
11	-66.832	-64.756
12	29.745	-75.383
13	100.000	-9.750
14	34.864	-67.964
15	-50.375	-90.462
16	77.295	-52.623
17	-96.708	-47.245
18	-85.638	-59.449

Guttman-Lingoes'
Coefficient of Alienation = 0.02633

Kruskal's Stress = 0.01814

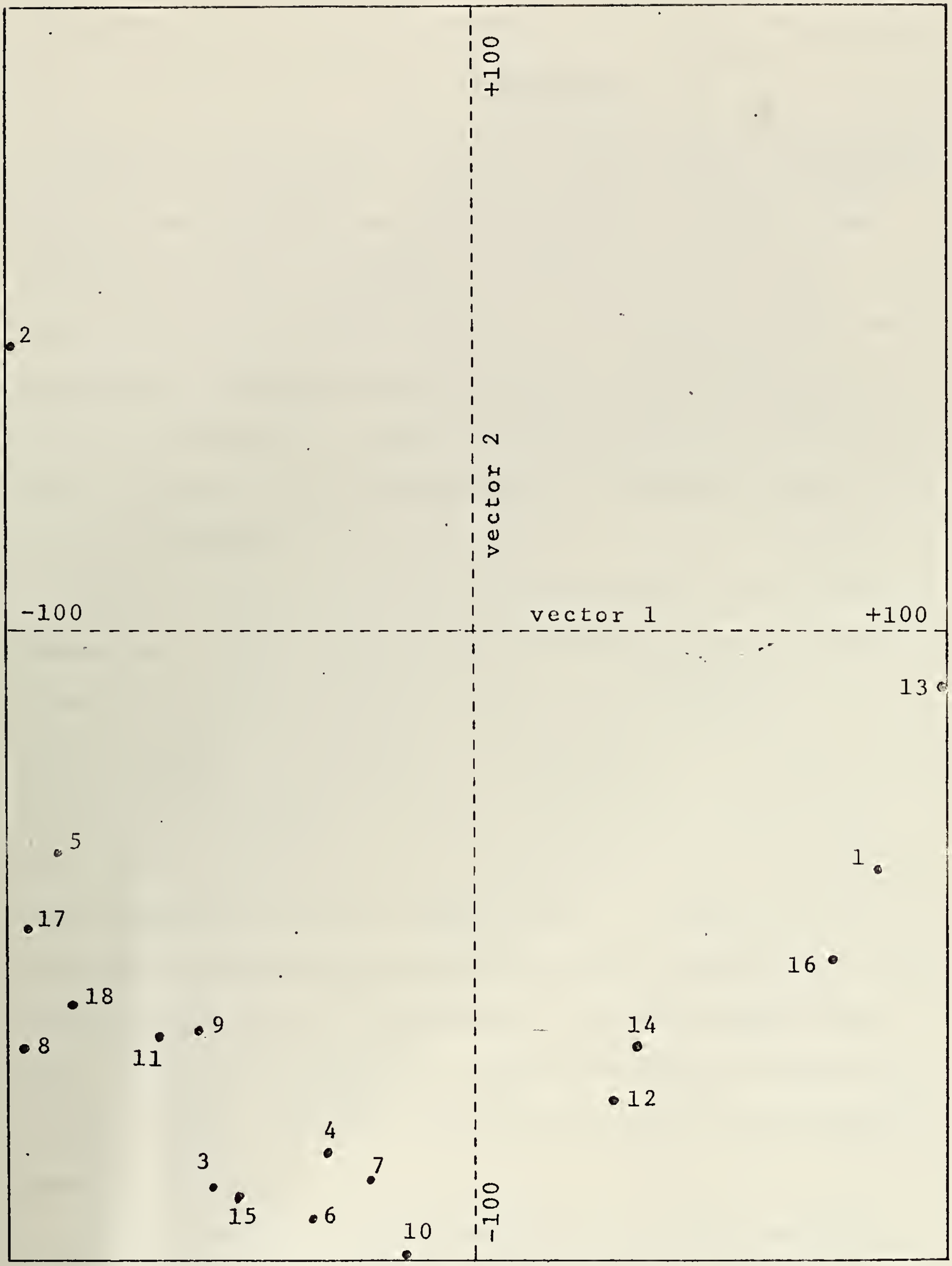

Figure 6. Plot of Projects when Ranked under Both Criteria.

VI. CONCLUSIONS

Results of the SSA-I plots of judge groups indicated that no two judge groups were in strong agreement when considering their rankings as a whole. Groups often agreed on which projects should be ranked high under one criterion or the other but disagreed on which projects should be ranked low. The reverse, agreeing on the lower ranked projects but disagreeing on the higher ranks, was also in evidence.

Different conclusions can be drawn from the project comparisons. The three plots using Criterion A, Criterion B, and both Criteria A and B, all displayed clustering tendencies. To display the results in an easy-to-read fashion the following was done. For each cluster, the mean rank of the projects in that cluster was calculated and designated the mean cluster rank. A ladder was constructed of ordered mean ranks for both clusters and non-clustered projects. The result is how the judge groups felt the projects should be ranked considering the three criteria above. Figure 7 displays the resulting project priority ladders.

Investigation of the variation in project rankings (Appendix E) shows which project was ranked most consistent by the judge groups. That project with the lowest standard deviation of ranking was project 17 with a mean

rank of 4.70 and a standard deviation of 1.68 for Criterion A, project 13 with a mean rank of 15.90 and a standard deviation of 1.87 for Criterion B, and project 13 with a mean rank of 15.74 and a standard deviation of 2.27 for Criteria A and B together.

Rank	Proj. No.	Project Title
1	2	Education and Training
2	11	Personnel Retention
3	17	Recruitment/Procurement
4	5	Manpower Requirements
	8	Selection/Classification
	18	Personnel Performance
5	6	Personnel Management Systems
6	3	Occupational Research and Development
	10	Career Structures
	12	Attitude/Motivation
	14	Organizational Effectiveness
	15	Distribution/Assignment
7	7	Man-Machine System R & D
	9	Applied Systems Development
8	4	Manpower/Personnel Cost Systems
	16	R & D Resources Management
9	1	Drug Abuse
10	13	Minority Discrimination Measurement and Reduction

Figure 7a. Project Priority Ladder as a Result of Clustering under the Military Significance Criterion.

Rank	Proj. No.	Project Title
1	2	Education and Training
2	9	Applied Systems Development
3	5	Manpower Requirements
4	4	Manpower/Personnel Cost Systems
5	8	Selection/Classification
6	3	Occupational Research and Development
	15	Distribution/Assignment
	17	Recruitment/Procurement
	18	Personnel Performance
7	6	Personnel Management Systems
	7	Man-Machine Systems R & D
	10	Career Structures
8	11	Personnel Retention
9	12	Attitude/Motivation
	16	R & D Resources Management
10	1	Drug Abuse
	13	Minority Discrimination Measurement and Reduction
	14	Organizational Effectiveness

Figure 7b. Project Priority Ladder as a Result of Clustering under the Investment Risk Criterion.

Rank	Proj. No.	Project Title
1	2	Education and Training
2	5	Manpower Requirements
	8	Selection/Classification
	17	Recruitment/Procurement
	18	Personnel Performance
3	9	Applied Systems Development
	11	Personnel Retention
4	3	Occupational Research and Development
	15	Distribution/Assignment
5	4	Manpower/Personnel Cost Systems
	6	Personnel Management Systems
	7	Man-Machine Systems R & D
6	10	Career Structures
7	12	Attitude/Motivation
	14	Organizational Effectiveness
8	1	Drug Abuse
	16	R & D Resources Management
9	13	Minority Discrimination Measurement and Reduction

Figure 7c. Project Priority Ladder as a Result of Clustering under both Criteria; Military Significance and Investment Risk.

APPENDIX A

LIST OF JUDGE GROUPS

Group Number	Group Composition
1	Manager personnel, Pers A-3
2	Manager personnel, Headquarters, Dept. of the Navy
3	Manager personnel, Naval Personnel Laboratory, Washington, D. C.
4	Professional worker, Naval Personnel Laboratory, San Diego
5	Professional worker, Naval Personnel Laboratory, Washington, D. C.
6	Manager personnel, Naval Personnel Laboratory, San Diego
7	Members, user panel (students at the Naval Postgraduate School)
8	Members, Laboratory Advisory Board for Personnel Laboratories
9	Technical/Professional persons, contractor activities
10	Fiscal year 1973 dollar funding for the specified project

APPENDIX B

LIST OF PROJECTS STUDIED

This Appendix lists the projects studied by identification number and short title, and includes a paragraph describing each. This information was available to each judge when he compiled his ranking.

Project No.	Short Title
1	Drug Abuse

This area consists of research and development for (a) determining causes, attitudes toward, and extent of drug abuse in the Navy; (b) exploration of means to reduce, prevent, and control drug abuse; and (c) means to provide effective education, counseling, and rehabilitation programs for Naval personnel and dependents.

Project No.	Short Title
2	Education and Training

The two mutually supporting purposes of Education and Training research and development are (a) improving Navy training and (b) development of principles and technology of training. Navy requirements call for more accurate definition of training requirements and for training methods directed toward meeting future job requirements. Research and development in this area involves work on the broad spectrum of problems related deriving and specifying appropriate training content and developing and evaluating ways to improve acquisition of training objectives. Research in this area also includes specific problems of learning, perception, job aids, programming, displays, simulation, and management as they relate to the improvement of training.

Project No.	Short Title
3	Occupational Research and Development

Development, test and evaluation of new and improved techniques for describing, evaluating, structuring, and re-engineering Navy occupations for optimal matching of available manpower characteristics to changing job requirements. Involves new methods for

determining skills required for effective performance of occupations and the storage and retrieval of occupational data pertaining to work requirements of Navy personnel.

4 Manpower/Personnel Cost Systems

Development, test and evaluation of new and improved (a) techniques for the acquisition, computation, storage, and retrieval of manpower/personnel cost data; (b) techniques for determining the cost of various mixes of men and equipment, personnel management policies, and personnel utilization factors; and (c) measures which permit manpower requirements planners to trade off cost and effectiveness in order to evaluate available options. The principal objective is to furnish total government costs from procurement through post-separation which can be used to formulate cost-related decisions concerning the total Navy manpower personnel systems.

5 Manpower Requirements

Development, test and evaluation of techniques for defining and displaying quantitative and qualitative manpower requirements for all functions performed ashore and afloat including upward aggregation of requirements to the total Navy establishment. The techniques must be responsive to the changing operational requirements, system design innovations, and available human resources. Includes the development of manpower/productivity models and the use of simulation techniques to test alternative manning and manpower management concepts in terms of cost and total system effectiveness. The principal objective is to develop methods for determining manpower requirements which are capable of responding quickly to changes in resources and military objectives and requirements.

6 Personnel Management Systems

Development, test and evaluation of tools to improve the quality of personnel management by increasing the accuracy of force projections, by responding more rapidly to changing policies and operational conditions, and by projecting the effects of current and proposed personnel policies to determine the most effective personnel management strategies. These tools are usually in the form of computerized models of the personnel system which can be used to reflect the relationship between such variables as recruit input, advancement, and attrition and to project the effect of these variables upon the size and skill composition of the personnel force.

7 Man-Machine R & D

This area is primarily concerned with the implementation of human operator considerations in the development, operations, and maintenance of new and current organizational, weapons and support systems. Goals include (a) an understanding of, and techniques to quantify and extrapolate, meaningful relationships among human performance, equipment characteristics, and environmental conditions; (b) development and application of man-machine standards, specifications, and tradeoff analysis methodologies in systems development, planning, and procurement; and (c) techniques for application of human capabilities to anticipated demand of future weapon systems.

8 Selection/Classification

The program area involves development, test and evaluation of new and improved methods for (a) more accurate and effective selection and classification of individuals; (b) determining their training requirements; and (c) matching the man to the job. Selection usually refers to the process of determining which individual or individuals should be accepted or rejected with regard to a specific program. Classification refers to determining and categorizing the appropriate skill qualifications of an individual that each school or job quota is filled with particular individuals most likely to perform successfully.

9 Applied Systems Development

Identification of personnel and training requirements, establishment of initial operator performance standards and maintenance skill requirements, assistance in man-machine tradeoff studies, and conducting studies to enhance man-machine compatibility for candidate and prototype systems under development. The effort frequently involves development of training objectives, review of course and lesson plans, and the evaluation of operator and maintenance personnel training.

10 Career Structure

Development, test and evaluation of new and improved techniques for (a) arriving at optimal career progression patterns; (b) methods for utilizing occupational, manpower/personnel cost, and other manpower factors data in determining optimal combination of grade and skill profiles required to satisfy Navy operational requirements; and (c) techniques for providing balance between needs of

the service based on technological projections, and needs of the individual related to opportunities for increased responsibility, advancement, prestige, and compensation. Typical outputs are optimum length of careers, optimal level of specialization, and optimum amount of fleet experience required of each grade of occupational specialty to meet changing military requirements.

11 Personnel Retention

This is a multi-faceted program exploring and developing methods and techniques for inducing qualified and needed personnel to remain on active duty, and programs which meet fluctuating needs of the naval service. Included are (a) investigation in psychometric technology to predict retention for use in selection and assignment; (b) development of more fair and effective evaluation of performance through computer-aided analysis and display of performance evaluation; and (c) development of improved techniques for selection and training of personnel in ratings which administer personal services to other naval personnel.

12 Attitude/Motivation

Develop sociometric and psychometric instruments and conduct controlled experiments for purposes of studying man's values, needs, aspirations, prejudices and expectations to achieve a better understanding of how they affect his thinking, feelings, and reactions to people, groups, social issues or events in his environment. The objective in achieving such an understanding is better prediction and control of an individual's behavior, motivation and performance.

13 Minority Discrimination Measurement and Reduction

This area is comprised of R & D support for BuPers and Navy objectives to intensify and expand efforts to eliminate racial, sex, and cultural discrimination and bias in the Navy.

14 Organization Effectiveness

Development and evaluation of techniques for measuring overall military effectiveness of organizational units under various contingencies. This involves the development of empirically based criteria and the relative importance of criteria which should be applied

in making judgments of organizational effectiveness. It includes studies of individual and organizational behavior and evaluative research into managerial practices and organizational characteristics. The principal objective is the enhancement of organizational effectiveness in relation to organizational goals and total system effectiveness.

15 Distribution/Assignment

This area encompasses research and development in the managerial functions of personnel distribution, assignment, and rotation as carried out by the Bureau of Naval Personnel. The program is concerned with the development and evaluation of new and improved techniques and procedures based on modern computer technology for (a) the equitable, quantitative and qualitative allocation ("distribution") of the personnel and inventory among the ships, aircraft squadrons, and shore stations of the Navy; (b) the optimal match ("assignment") of specific individuals to particular billets in terms of prescribed criteria; and (c) the planned, periodic reassignment ("rotation") of career personnel to the various categories of sea, shore and overseas duty. Objectives are the optimum matching of personnel and billets, improved manpower utilization systems, and optimal matching of manpower requirements and resources over time.

16 R & D Resources Management

This area includes three subareas dealing with efficient use of R & D resources. One deals with the selection and evaluation of scientific/research personnel employed by the laboratories. Research in this area is aimed at the development of performance evaluation criteria in the area of quantitative and qualitative work output and scientific/technical contributions. Another subarea concerns the identification of significant problem areas, assignment of priorities, and selection of tasks to be performed to assure maximum return for the"R & D dollar". A third subarea is the continuing study of the implementation of research recommendations by consumers as a basis for future research planning and to facilitate the implementation of significant R & D products.

17 Recruitment/Procurement

Development, test and evaluation of methods and techniques for (a) attracting and obtaining

required skill composition, racial mix, and educational levels and for (b) improving selection policies and programs relating to manpower requirements, implications of an all volunteer force, manpower ceilings reductions, and changes in strategic guidance. The principal objective is to obtain personnel with the appropriate innate and acquired characteristics to meet all of the performance requirements and changing requirements of future naval forces.

18 Personnel Performance

Development of on-the-job performance standards and criteria and improved proficiency measurement techniques to assure that selection, assignment, and promotion factors are job-relevant. The goal is maximum readiness of individuals and units.

APPENDIX C

MATRIX M

M_{ij}: that project ranked in the I^{th} position by judge group j.

	Judge Groups																		
	Criterion A										Criterion B								
Rank Priority Number	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9
1	17	5	5	2	11	2	11	11	2	2	2	9	9	2	9	2	2	7	2
2	11	11	3	8	18	18	18	2	18	6	9	17	3	15	5	15	18	18	7
3	2	17	9	11	5	8	2	14	11	10	6	3	2	5	4	8	15	5	9
4	5	4	17	17	2	11	10	12	12	9	3	5	10	4	7	9	8	9	4
5	6	8	7	18	7	17	5	8	14	17	5	6	5	17	2	4	11	17	18
6	4	15	2	12	6	15	17	17	17	5	15	15	4	9	18	18	4	4	17
7	18	6	8	16	17	5	12	10	15	3	4	8	8	8	3	5	3	8	5
8	3	2	10	14	14	6	8	6	10	12	8	2	15	18	8	7	5	2	16
9	8	3	11	15	8	9	14	3	7	18	17	7	7	3	17	6	1	3	8
10	1	14	1	3	9	3	15	18	9	15	10	4	6	10	11	3	12	10	10
11	13	18	18	5	4	14	3	15	13	8	11	10	18	7	14	10	10	11	6
12	15	12	6	6	12	4	6	16	8	11	16	11	17	6	6	17	9	15	13
13	7	7	12	1	16	7	1	9	1	7	1	18	11	16	15	16	17	16	15
14	12	10	15	7	10	10	7	4	6	4	7	14	1	11	10	13	7	6	11
15	14	9	14	9	3	16	16	13	5	13	18	16	14	13	12	11	6	14	3
16	10	13	4	13	15	12	9	5	3	1	12	13	12	12	1	14	13	1	12
17	16	16	16	10	1	13	4	1	16	14	13	12	16	14	16	1	14	12	1
18	9	1	13	5	13	1	13	7	4	16	14	1	13	1	13	12	16	13	14

MATRIX N

n_{ij} = rank position at project I by judge group j

	Judge Groups																		
	Criterion A										Criterion B								
Project Number	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9
1	10	18	10	13	17	18	13	17	13	16	13	18	14	18	16	17	9	16	17
2	3	8	6	1	4	1	3	2	1	1	1	8	3	1	5	1	1	8	1
3	8	9	2	10	15	10	11	9	16	7	4	3	2	9	7	10	7	9	15
4	6	4	16	18	11	12	17	14	18	14	7	10	6	4	3	5	6	6	4
5	4	1	1	11	3	7	5	16	15	6	5	4	5	3	2	7	8	3	7
6	5	7	12	12	6	8	12	8	14	2	3	5	10	12	12	9	15	14	11
7	13	13	5	14	5	13	14	18	9	13	14	9	9	11	4	8	14	1	2
8	9	5	7	2	9	3	8	5	12	11	8	7	7	7	8	3	4	7	9
9	18	15	3	15	10	9	16	13	10	4	2	1	1	6	1	4	12	4	3
10	16	14	8	17	14	14	4	7	8	3	10	11	4	10	14	11	11	10	10
11	2	2	9	3	1	4	1	1	3	12	11	12	13	14	10	15	5	11	14
12	14	12	13	6	12	16	7	4	4	8	16	17	16	16	15	18	10	17	16
13	11	16	18	16	18	17	18	15	11	15	17	16	18	15	18	14	16	18	12
14	15	10	15	8	8	11	9	3	5	17	18	14	15	17	11	16	17	15	18
15	12	6	14	9	16	6	10	11	7	10	6	6	8	2	13	2	3	12	13
16	17	17	17	7	13	15	15	12	17	18	12	15	17	13	17	13	18	13	8
17	1	3	4	4	7	5	6	6	6	5	9	2	12	5	9	12	13	5	6
18	7	11	11	5	2	2	2	10	2	9	15	13	11	8	6	6	2	2	5

APPENDIX D

JUDGE GROUP CORRELATION MATRIX R

	1	2	3	4	5	6	7	8	9
1	1.00								
2	.74	1.00							
3	.29	.30	1.00						
4	.40	.38	.14	1.00					
5	.53	.55	.38	.47	1.00				
6	.60	.69	.41	.65	.69	1.00			
7	.45	.47	.36	.65	.59	.62	1.00		
8	.24	.36	-.01	.69	.32	.48	.65	1.00	
9	.12	.07	.04	.54	.41	.43	.67	.60	1.00
10	.31	.30	.60	.10	.30	.48	.43	.31	.25
11	.33	.41	.53	.02	.14	.49	.04	.05	-.25
12	.30	.52	.69	.02	.26	.56	.05	.01	-.16
13	.11	.29	.68	-.16	.15	.42	.13	-.03	-.13
14	.37	.55	.43	.12	.26	.65	.19	-.03	-.01
15	.30	.46	.64	.00	.59	.54	.12	-.11	-.01
16	.17	.35	.31	.06	.24	.63	.03	-.10	-.03
17	.47	.46	.27	.38	.26	.64	.53	.23	.31
18	.26	.36	.65	.04	.58	.54	.21	-.21	.02
19	.17	.12	.34	-.03	.44	.39	-.02	-.23	.01

****

	10	11	12	13	14	15	16	17	18
10	1.00								
11	.68	1.00							
12	.64	.79	1.00						
13	.65	.80	.74	1.00					
14	.54	.72	.72	.72	1.00				
15	.37	.52	.65	.72	.65	1.00			
16	.43	.69	.63	.73	.88	.64	1.00		
17	.30	.38	.17	.48	.56	.39	.56	1.00	
18	.33	.36	.60	.61	.67	.86	.63	.35	1.00
19	.35	.41	.43	.48	.68	.66	.69	.18	.78

APPENDIX E

DATA ON INDIVIDUAL PROJECT RANKINGS FOR SPECIFIED CRITERION

Proj.No.	Criterion A Mean	STD	Criterion B Mean	STD	Criteria A&B Mean	STD
1	14.50	2.94	15.40	2.62	14.89	2.88
2	3.00	2.28	3.00	2.79	3.11	2.57
3	9.70	3.74	7.30	3.61	8.58	3.95
4	13.00	4.60	6.50	3.11	9.53	5.13
5	6.90	5.13	5.00	1.90	5.95	4.08
6	8.60	3.61	9.30	4.29	9.32	3.74
7	11.70	3.93	8.50	4.54	9.95	4.61
8	7.10	3.14	7.10	2.17	6.89	2.61
9	11.30	4.78	3.80	3.16	7.74	5.60
10	10.50	4.82	9.40	3.17	10.32	3.89
11	3.80	3.54	11.70	2.69	7.53	5.08
12	9.60	4.10	14.90	3.08	12.47	4.50
13	15.50	2.50	15.90	1.87	15.74	2.27
14	10.10	4.28	15.80	2.04	12.74	4.41
15	10.10	3.14	7.50	4.15	8.74	4.00
16	13.80	4.77	14.40	3.04	14.42	3.10
17	4.70	1.68	7.80	3.54	6.32	3.25
18	6.10	3.75	7.70	4.15	6.79	4.11

PROJECT DISSIMILARITY MATRIX T_A

	1	2	3	4	5	6	7	8	9
1	0.0								
2	4.44	0.0							
3	1.45	2.29	0.0						
4	.41	3.09	.79	0.0					
5	1.96	1.14	.64	1.26	0.0				
6	1.81	1.95	.30	1.08	.40	0.0			
7	.82	2.91	.52	.31	1.07	.82	0.0		
8	2.43	1.53	.76	1.55	.05	.45	1.31	0.0	
9	.85	2.52	.38	.36	.89	.65	.09	1.08	0.0
10	1.06	2.26	.19	.53	.72	.46	.28	.87	.17
11	3.31	.28	1.62	2.28	.73	.34	2.12	.99	1.82
12	1.41	2.16	.03	.78	.59	.26	.52	.70	.38
13	.37	5.24	1.90	.74	2.40	2.30	1.21	3.00	1.22
14	1.24	2.27	.10	.65	.68	.38	.39	.82	.27
15	1.45	2.65	.12	.76	.80	.45	.46	.95	.31
16	.19	3.27	.97	.17	1.40	1.25	.49	1.73	.52
17	4.41	.87	2.00	2.99	.75	1.59	2.73	1.05	2.33
18	2.53	1.06	.96	1.66	.18	.68	1.46	.29	1.23

****

	10	11	12	13	14	15	16	17	18
10	0.0								
11	1.62	0.0							
12	.20	1.52	0.0						
13	1.44	3.93	1.84	0.0					
14	.09	1.62	.12	1.65	0.0				
15	.10	1.89	.14	1.93	0.0	0.0			
16	.69	2.43	.95	.49	.82	.96	0.0		
17	2.04	.37	1.87	5.28	2.02	2.35	3.22	0.0	
18	1.03	.63	.89	3.07	1.00	1.16	1.82	.56	0.0

PROJECT DISSIMILARITY MATRIX T_B

	1	2	3	4	5	6	7	8	9
1	0.0								
2	4.59	0.0							
3	2.64	1.35	0.0						
4	3.12	1.19	.24	0.0					
5	4.67	.87	.88	.62	0.0				
6	1.82	1.82	.51	.77	1.51	0.0			
7	2.00	1.54	.30	.53	1.19	.18	0.0		
8	3.49	1.67	.07	.23	1.04	.72	.45	0.0	
9	4.04	.27	1.04	.86	.49	1.49	1.24	1.26	0.0
10	2.08	2.15	.62	.92	1.79	.03	.24	.88	1.77
11	1.40	3.18	1.41	1.80	2.97	.71	.92	1.91	2.71
12	.18	4.06	2.28	2.72	4.09	1.54	1.71	3.02	3.56
13	.23	5.65	3.31	3.90	5.79	2.33	2.54	4.38	4.98
14	.17	5.36	3.13	3.69	5.49	2.20	2.40	4.14	4.73
15	2.40	1.32	.05	.28	.89	.43	.23	.13	1.02
16	.35	3.91	2.14	2.57	3.91	1.41	1.59	2.85	3.42
17	2.50	1.53	.14	.39	1.08	.38	.17	.25	1.20
18	2.34	1.38	.10	.33	.96	.38	.18	.20	1.08

****

	10	11	12	13	14	15	16	17	18
10	0.0								
11	.79	0.0							
12	1.76	1.11	0.0						
13	2.76	1.88	.42	0.0					
14	2.52	1.75	.36	.05	0.0				
15	.52	1.26	2.07	3.02	2.85	0.0			
16	1.61	.95	.16	.63	.56	1.94	0.0		
17	.48	1.26	2.15	3.15	2.98	.08	2.01	0.0	
18	.47	1.20	2.01	2.95	2.78	.05	1.89	.03	0.0

PROJECT DISSIMILARITY MATRIX T_{AB}

	1	2	3	4	5	6	7	8	9
1	0.0								
2	4.33	0.0							
3	1.87	1.72	0.0						
4	1.40	1.77	.21	0.0					
5	2.61	.88	.66	.78	0.0				
6	1.70	2.00	.19	.05	.86	0.0			
7	1.36	1.99	.32	.09	.92	.15	0.0		
8	2.91	1.46	.52	.72	.29	.77	.88	0.0	
9	1.78	1.22	.18	.33	.37	.34	.44	.22	0.0
10	1.37	2.28	.44	.18	1.10	.26	.09	1.07	.55
11	1.93	1.22	.23	.39	.35	.41	.50	.17	.04
12	.67	2.75	.92	.61	1.52	.77	.55	1.63	.94
13	.33	5.23	2.39	1.82	3.22	2.20	1.79	3.63	2.25
14	.61	2.86	1.00	.67	1.60	.84	.62	1.72	1.01
15	1.81	1.76	.04	.17	.69	.15	.28	.57	.21
16	.16	4.01	1.67	1.23	2.38	1.50	1.18	2.64	1.60
17	2.81	1.11	.63	.79	.10	.86	.94	.20	.33
18	2.35	1.13	.44	.60	.21	.64	.73	.03	.20

****

	10	11	12	13	14	15	16	17	18
10	0.0								
11	.63	0.0							
12	.52	1.03	0.0						
13	1.82	2.42	1.02	0.0					
14	.58	1.10	.06	.95	0.0				
15	.40	.27	.88	2.32	.95	0.0			
16	1.18	1.74	.52	.50	.46	1.61	0.0		
17	1.13	.30	1.61	3.47	1.70	.67	2.56	0.0	
18	.88	.16	1.32	2.93	1.40	.48	2.14	.13	0.0

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13. ABSTRACT

The problem is defined as examining a list of the research projects presently sponsored by the Department of the Navy under GOR-43 and analyze the ordered project listings as ranked by panels composed of persons with interest in those projects.

Data consisted of project priority rankings of 193 judges composing 9 separate panels, each judge ranking the projects twice in priority order; once considering the practical significance of the project and once considering the possibility of a successful research effort. Project rankings of judges within each panel were scaled using the FORD procedure and the 9 panel rankings then investigated for similarities using methods of cluster analysis.

The results showed that no 2 judge panels submitted highly correlated rankings of the 18 projects, but that under each criterion several project clusters were evident, indicating equal research emphasis desired by the panels.

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Ordered rankings						
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